Original Article

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Necessity of In-hospital Neurological Observation for Mild Traumatic Brain Injury Patients with Negative Computed Tomography Brain Scans

Chin Taweesomboonyat, M.D., Anukoon Kaewborisutsakul, M.D., Thara Tunthanathip, M.D., Sakchai Saeheng, M.D., Thakul Oearsakul, M.D.

Division of Neurosurgery, Department of Surgery, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.

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Abstract:

Objective: The authors aimed to evaluate the necessity of in-hospital neurological observation for mild traumatic brain injury (TBI) patients, who did not have any evidence of intracranial injury from initial computed tomography (CT) brain scans.

Material and Methods: We retrospectively reviewed mild TBI patients with initial negative CT brain scans, receiving treatment at Songklanagarind hospital between January and December, 2018. All patients were observed in the emergency department short stay observation unit for 24 hours after injury. Patients' medical records, initial and official CT brain scan interpretation were collected and analyzed.

Results: This study included 493 cases. No patient deteriorated from intracranial injury, while one patient deteriorated from hypoglycemia, associated with his underlying adrenal insufficiency. However, one patient was admitted to the in-patient ward, due to a missed diagnosis of acute subdural hematoma from his initial CT interpretation. The incidence of missed intracranial injury from initial CT brain scan interpretation was 1.6%. The need for neurosurgical intervention (in-patient ward admission, anticonvulsant and repeat brain imaging) was 0.2% (1/493). No patient required surgical intervention.

Contact: Chin Taweesomboonyat, M.D.
Division of Neurosurgery, Department of Surgery, Faculty of Medicine,
Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.
E-mail: chin.3ch@hotmail.com

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Conclusion: Mild TBI patients, with initial negative CT brain scans, have very low risk for deterioration or need of neurosurgical intervention. Patient's underlying major comorbidity may be considered as an indication for in-hospital observation.

Keywords: computed tomography brain scan, in-hospital neurological observation, mild traumatic brain injury

Introduction

Mild traumatic brain injuries (TBI) are a common problem in neurosurgical practice around the world, and can occur in any age group of the population. Mild TBI can cause many symptoms, such as headaches, nausea, vomiting, memory impairment, vertigo, or insomnia. Therefore, this condition may not be "mild" for some patients as its name suggests.

Seventy-five to ninety-five percent of traumatic brain injury cases are mild.[1] Mild TBI is defined by the Glasgow Coma Scale (GCS) score of 13-15 in traumatic brain injury patients. Six to ten percent of mild TBI patients have abnormalities on brain imaging, such as cortical contusions or intracranial hemorrhage[2], although, only 1.0% of mild TBI patients require neurosurgical intervention (death within 7 days, or need for any of the following: craniotomy, elevation of depressed skull fracture, intracranial pressure monitoring or intubation for head injury).[3]

Mild TBI patients, with negative findings on neuroimaging, have a very low risk for neurosurgical intervention or new emerging intracranial lesions. However, patients at risk for immediate complications from head injuries, such as progressive headaches, persistent vomiting or coagulopathy, may need in-hospital observation at the emergency department due to concerns of neurological deterioration.

The benefit of in-hospital or emergency department short observation for patients with mild TBI and negative CT brain scans is not well addressed. Howbeit, there are evidences that patients with mild TBI and negative CT brain scans may deteriorate, especially for patients with risk factors, such as coagulopathy or platelet dysfunction.[4] Therefore, this study aimed to evaluate the benefits of short observation (24 hours in duration) for mild TBI patients, who did not have any evidence of intracranial injury from their initial CT brain scan.

Material and Methods

We retrospectively reviewed consecutive patients with mild TBI and negative CT brain scans, who had been neurologically observed at the emergency department short stay observation unit (SOU) of Songklanagarind hospital, a tertiary care center and medical school in the southern part of Thailand, between January 2018 and December 2018. In this study, a negative CT brain is defined as no calvarial fracture or intracranial hemorrhage, therefore the patients may have had a maxillofacial injury or fracture. Our institute's policy, or criteria, for CT brain scans in mild TBI patients follows the Canadian CT head rules. Patients who were in the high or medium risk group were investigated with a non-contrast CT brain scan. Furthermore, patients who had a history of antiplatelet or anticoagulant usage were also investigated with a non-contrast CT brain scan. It is our hospitals protocol that every mild TBI patient with a negative CT brain scan should be observed at the emergency department SOU, for at least 24 hours, due to concerns of deterioration. Therefore, all mild TBI patients, with negative CT brain scans, in our hospital had been neurologically observed at the emergency department SOU, for at least 24 hours before discharge. Mild TBI patients, who had intracranial hemorrhage, cavarial fractures or had other indications for admission; for example, associated intraabdominal injuries, were admitted to a trauma patient ward or intensive care unit (not included in this study). CT brain scanning was initially interpreted by a neurosurgical resident, and patients were managed according to these results. Most radiologists officially reported the results of CT brain scans later than 6 hours after scanning.

During observation, patients were neurologically evaluated (GCS score, muscle power, and pupils) every hour, for a 24 hour period, and they were also restricted as to oral intake (non per oral; NPO) during observation. After a 24 hour period of observation, the patients were discharged; if they did not have clinical deterioration, or any other problems that required admission.

Data and medical records regarding patient demographics, comorbidities, current medication, mechanism of injury, clinical presentation, associated injury, laboratory and CT brain scan results, patient's neurological status along with treatment intervention during observation were reviewed, collected and analyzed. The patient's neurological status at 1 week follow up was also collected.

For primary outcome (deterioration of neurological status and neurosurgical intervention), due to the low number of patients with secondary deterioration, only descriptive statistics were applied.

Age, gender, comorbid conditions (diabetes, hypertension, underlying brain disease), anticoagulant or antiplatelet medication use, GCS score, clinical presentation, associated injury, CT brain scan result, patients' clinical status during observation and treatment intervention were analyzed. Statistical analyses were performed using the R Program (version 3.6.1; R Foundation, Vienna, Austria) and the Epidemiological calculator (R epicalc package). A p-value<0.05 was considered to be statistically significant.

Results

Four hundred and ninety-three patients were included in the study. Table 1 shows the baseline characteristics of the patients. Fifty-four percent of the patients were male, with the median age being 65 years (interquartile range 36, 78). Sixty-one percent of patients had at least one underlying disease. Sixteen percent of patients had an underlying brain disease, whist only one percent had had a history of brain surgery. Three and nineteen percent of patients were on an anticoagulant and antiplatelet, respectively. Twenty percent of injuries were asso-ciated with alcohol intoxication. The most common mechanism of injury was falling (50.0%), followed by motor vehicle accident (38.0%) and a fall from height (3.7%). Ninety-five, five and one percent of patients had a GCS score of 15, 14, and 13, respectively. The common symptoms of patients were amnesia (38.0%), transient loss of consciousness (34.0%), and headache (26.0%). Eleven percent of patients had associated bone and maxillofacial injury. Two percent of CT brain scans were initially interpreted by a neurosurgery resident as no intracranial hemorrhage or calvarial fracture, but later reported by a radiologist as positive for either intracranial hemorrhage or calvarial fracture, additionally 3 percent were reported as inconclusive for intracranial injury (the lesion was not definitely confirmed, nor excluded to be evident of intracranial injury). Table 2 shows details of the patients with missed intracranial hemorrhage or calvarial fractures on initial CT brain scan interpretation. Most missed injuries were thin, acute subdural hematomas, and small, acute subarachnoid hemorrhages. Only one patient had neurological status deterioration, due to hypoglycemia associated with his underlying adrenal insufficiency. No patient had neurological status deterioration from intracranial injury, nor did any patient require surgical intervention, nor any medication for brain edema.

Table 1 Baseline characteristics of the patients (n=493)

Characteristic	Number (%)
Male	267 (54.2)
Age, median (IQR)	65 (36,78)
Comorbidities	302 (61.3)
Diabetes mellitus	67 (13.6)
Hypertension	194 (39.4)
Underlying brain disease	77 (15.6)
History of brain surgery	5 (1.0)
Anticoagulant use	13 (2.7)
Antiplatelet use	94 (19.3)
Alcohol intoxication	99 (20.1)
Mechanism of injury	
Motor vehicle accident	185 (37.5)
Pedestrian injury	4 (0.8)
Falling	245 (49.7)
Fall from height	18 (3.7)
Sport-related injury	5 (1.0)
Other mechanisms	36 (7.3)
Glasgow coma scale score	
13	4 (0.8)
14	21 (4.3)
15	468 (94.9)
Symptoms	
Transient loss of consciousness	159 (34.1)
Amnesia	182 (38.2)
Headache	126 (25.6)
Nausea/ vomiting	67 (13.6)
Dizziness/ vertigo	64 (13.0)
Seizure	13 (2.6)
Associated injury	
Chest	3 (0.6)
Abdomen	1 (0.2)
Spine	5 (1.0)
Bone and extremities	56 (11.4)
Maxillofacial injury	52 (10.5)
Official CT brain scan result	
Negative	470 (95.3)
Positive for intracranial injury	8 (1.6)
Inconclusive	15 (3.0)
Deterioration of neurological status during observation	1 (0.2)
In-patient admission	1 (0.2)
Anticonvulsant	1 (0.2)
Repeat brain imaging	1 (0.2)
IV pain control	35 (7.1)
IV antiemetic drugs	4 (0.8)
Other IV medication (mostly were antibiotics for lacerated wound)	113 (22.9)
Blood transfusion	1 (0.2)
Wound management	1 (0.2)
Other intervention	3 (0.6)
Neurological status at 1 week follow up	
Stable	378 (76.7)
Deterioration	0
Loss follow up	115 (23.3)

Data are presented as n (%), unless indicated otherwise
CT=computed tomography, INR=international normalized ratio, IQR=interquartile range, IV=intravenous

One patient had a delayed diagnosed of a right frontotemporal acute subdural hematoma (missed injury on the preliminary reading). This patient was admitted to the trauma patient ward for neurological observation, follow up CT brain scanning for hematoma progression wherein they were prescribed an antiepileptic drug, for early post-traumatic seizure prophylaxis. The patients' clinical status was stable without neurological deterioration. Follow up CT brain scanning showed a stable acute subdural hematoma, without any indication for surgical intervention being required. Figure 1 shows a flow chart of the patients in this study.

During short observation at the emergency department SOU, 7.0% and 1.0% of patients received intravenous (IV) pain control coupled with antiemetic medication, respectively. Twenty-three percent of patients received other IV medication, from which 89.0% of these were antibiotics for external wounds. One patient required a blood transfusion, due to chronic anemia from underlying lymphoplasmacytic lymphoma in his bone marrow. One patient required wound management, due to active bleeding from an avulsion wound at the forehead, whilst three patients required other interventions; not associated with traumatic brain injury. At 1 week after injury, 23.0%

Table 2 Details of the Patients with Missed Intracranial Hemorrhage or Calvarial Fracture on Initial CT Brain Scan Interpretation

No.	Gender	Age (years)	Official CT brain scan result by radiologists	Further management according to an official CT scan result	Patients' clinical status during and after in-hospital observation
1	Male	24	A near non-displaced linear fracture of left occipital bone	None	Stable
2	Male	36	Thin acute SDH (3 mm thick) along posterior interhemispheric falx and bilateral tentorium cerebelli	None	Stable
3	Male	73	A linear non-displaced skull fracture of right occipital bone down to left occipital condyle	None	Stable
4	Male	45	A small acute SAH at left frontal sulci	None	Stable
5	Male	59	A thin (2 mm) acute SDH along right tentorium cerebelli	None	Stable
6	Male	84	Minimal acute SAH along right temporal sulci with adjacent thin SDH	Follow up CT brain at 1 week follow up	Stable
7	Female	81	A minimal acute SAH along right frontal sulci	None	Stable
8	Female	92	A thin SDH (4 mm) at right frontotemporal convexity	Admitted to trauma patient ward and follow up CT brain scan	Stable

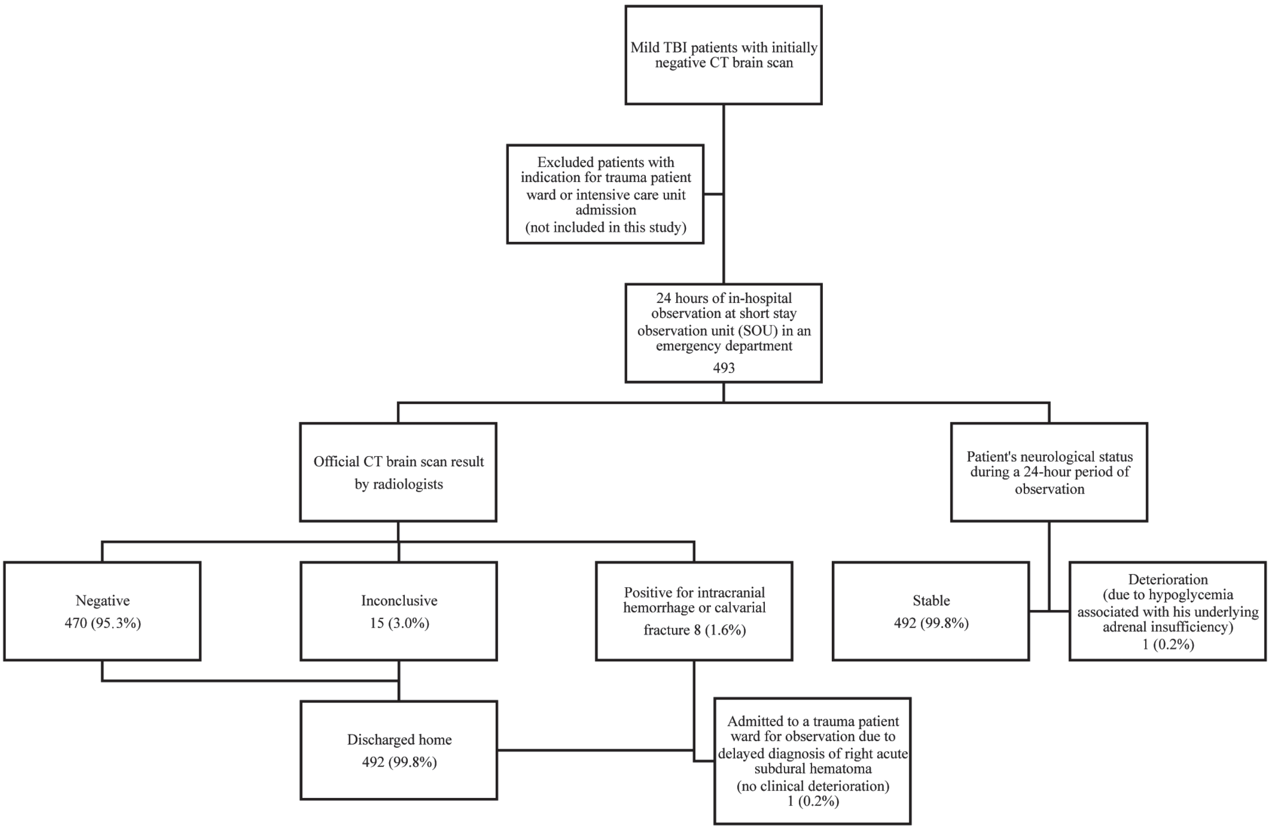
CT=computed tomography, SDH=subdural hematoma, SAH=subarachnoid hemorrhage, mm=millimeter

of patients were lost to follow up. All of the patients that came for follow up were neurologically stable.

Discussion

The patients in our study consisted mainly of aging patients, whom had been treated for mild TBI, occurring from falling mechanism. These patients differ from the patients in previous studies, in that these mild TBIs were a result from either body assault[5] or a motor vehicle accident.[6,7] Currently, there is an increasing trend among patients of age having suffered from mild TBIs due to falling mechanism, with this now becoming the major cause of mild TBIs worldwide. Hence, this study probably better reflects the real population of mild TBI patients in the current climate.

More than half of the patients had underlying diseases, and about one-fifth of the patients were on anti-coagulant or antiplatelet drugs. Previous studies showed that 0.4-6.0% of the patients on anticoagulant or anti-platelet drugs had delayed, traumatic intracranial hemor-rhage despite initial CT brain scans being normal.[4,8–10] Nishijima et al. found that warfarin significantly increased the risk of delayed traumatic intracranial hemorrhage, while clopidogrel did not.[9] However, the risk for neurosurgical intervention in these patients was only 0.0-1.0%.[4,8–10] These studies signify the importance of neurological observation, for both the in-hospital and after discharge periods, so as to detect clinical deterioration and to establish appropriate management for this group of patients.



Data are presented as n (%) unless indicated otherwise.

TBI=traumatic brain injury, CT=computed tomography

Figure 1 Flow chart of mild traumatic brain injury patients in this study

In this study, no patient had neurological deterioration from intracranial injury. Although, one patient had deterioration of their neurological status, from hypoglycemia associated with his underlying adrenal insufficiency. Additionally, although no patient had deterioration of neurological status, one patient had been admitted from the emergency department SOU to the in-patient ward for neurological observation, prophylactic anticonvulsant, and follow up CT brain scanning, due to missed injury (acute subdural hematoma) from initial CT brain scan interpretation. Repeated CT brain scanning, for this patient, revealed a stable, acute subdural hematoma. The patient did not require any surgical intervention. The incidence of missed intracranial injury, from initial CT brain scan interpretation (CT was initially interpreted as negative, but later reported by a radiologist as positive for intracranial injury), in a previous study was 1.1%[6], comparable to 1.6% in this study. Most missed injuries in a previous study were contusions, subarachnoid hemorrhage, and subdural hematoma, respectively, which is consistent with subdural hematomas and subarachnoid hemorrhages in this study. The reliability of initially negative readings from CT brain scans has rarely been addressed in previous studies. Hence, this is of particular concern, as well as an important point to consider, before constructing an appropriate management strategy according to said CT results.

In patients where initial CT brain scans were negative for intracranial injury, the need for neurosurgical intervention (intensive care unit admission, anticonvulsants or antiedema medications or craniotomy) in previous studies was 0.0-0.3%[6,11], comparable to 0.2% (1/493) in this study. Only one patient in this study required intervention, due to missed injury (acute subdural hematoma) from the preliminary reading. The interventions for this patient were: in-patient admission, follow up CT brain scan and prescription of an antiepileptic drug for early post-traumatic seizure prophylaxis. In so saying, the intervention in this study was actually associated with an initial misinterpretation of the CT brain scan.

The patients in this study were older (median 65 years in this study vs. mean 30.9-38.0 years in previous studies)[5-7,11], and had different major mechanisms of injury (as mentioned previously) compared to previous studies. Therefore, this study may represent the data in a different subgroup of mild TBI patients.

Mild TBI patients without intracranial injury from initial CT brain scans are at very low risk for deterioration or in need of neurosurgical intervention. However, the risk may be further stratified by the patient's underlying status, anticoagulant/antiplatelet use, mechanism of injury, symptoms and clinical status. Previous studies found that the use of anticoagulants and severity of symptoms were associated with delayed intracranial complications.[9,12] In our opinion, mechanism of injury may also be used to stratify the risk for delayed intracranial complications. The limitations of the present study should be acknowledged. First, a retrospective study design led to bias, due to no control of confounding factors. Second, mild TBI patients that had been admitted, due to significant associated injury, were excluded from this study. Therefore, the higher risk group of patients might have been excluded from the study. Third, there were about one-fifth of patients that were lost to follow up at 1 week after injury. Thus, the patient's status at short term follow up could not be evaluated accurately.

The strengths of this present study were that all patients had been observed at the emergency department SOU for at least 24 hours, which enabled us to evaluate the patient's status, along with the need for treatment intervention in all cases. Second, this study represented mild TBI patients that had mostly occurred from falling mechanism. Currently, this group of patients is increasing and becoming the major cause of mild TBIs around the world. Therefore, this study represents data that is compatible with the current global situation. Finally, this study represents the incidence of initial misinterpretation of CT brain scanning. This aspect of preliminary CT scan interpretation has rarely been addressed in previous studies.

Conclusion

Mild TBI patients, with initial negative CT brain scans, are at very low risk for deterioration or the requirement for neurosurgical intervention. However, there is much diversity in patients' underlying medical status, mechanism of injury, clinical presentation, associated injury and especially the accuracy of initial CT brain scan interpretation. Stratification of mild TBI patients, according to these factors, should help in tailoring appropriate management for each patient, so as to avoid the overuse of medical resources. Patient's underlying, major comorbidity may be considered as an indication for in-hospital observation. This is due to the risk of deterioration from their underlying conditions.

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Conflict of interest

There are no potential conflicts of interest to declare.

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